NATIONAL HYDRIC SOILS WORKSHOP
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HYDRIC SOILS DEFINITION, CRITERIA AND INDICATORS

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Hydric soils, hydrophytic vegetation and wetland hydrology are the three parameters used in identifying and delineating wetlands. Hydric soils are defined in the Federal Register, July 13, 1994, "as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part." For the practicing field person, it is important to understand terms such as criteria, and field indicators. Criteria are selected soil properties that are documented in Soil Taxonomy (Soil Survey Staff, 1999) and were designed primarily to generate a list of hydric soils from the national database of Map Unit Interpretation Records (MUIR). Field Indicators are soil characteristics, which are documented to be strictly associated only with hydric soils. The Field Indicators are designed to identify soils, which meet the hydric soil definition without further data collection.

HISTORY OF THE HYDRIC SOIL CONCEPT

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The term hydric soils was coined over 20 years ago and the concept has evolved over the years. The term refers to the substratum that supports the growth of hydrophytic plants and early definitions were developed to adapt the concept to the regulatory arena. Congress directed NRCS (then called SCS) to develop a listing of hydric soils in the U.S. This effort was, and still is, limited to retrieval of computer stored taxonomic and hydrological information. To facilitate the retrieval process criteria were developed. Over time these criteria were fine-tuned and for many years defined soil characteristics used for wetland delineation. National and regional hydric soil lists have been published by NRCS, but these lists are not all-inclusive. They generally do not contain the names of soil series that at times may be hydric, but under certain conditions are non-hydric. Various delineation manuals (EPA, ACOE, FWS) included references to hydric soils and listed their properties. Unfortunately, these characteristics were in general terms and often did not provide sufficient detail to be useful to the practicing wetland delineator. Not until the mid-1990's did the National Hydric Soils Committee develop field indicators that were specific. Further development of the field indicators is an on-going process, in particular for regional applications.

PEDOGENESIS OF HYDRIC SOILS

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Roy Simonson's generalized model for pedogenesis underlines the importance of additions, losses, transfers, and transformations, and pedogenesis within hydric soils can be understood within this same framework. The basic conditions requisite for hydric soils are saturation leading to anaerobiosis in the upper part of the soil. Under these conditions, there are two fundamental processes related to pedogenesis of hydric soils: 1) the transformation of iron oxides by biogeochemical reduction and the subsequent transfer of Fe oxides within, or loss from, the soil; and 2) a shift in the balance between additions and losses of organic matter (OM) in the soil and related biogeochemical transformations of soil OM. Processes related to Fe oxides result in the formation of depletions or concentrations of Fe in a variety of locations within the soil. Particular profile or landscape hydrological factors may contribute to more significant depletions of Fe (depleted matrices) or in some cases to the presence of reduced matrices. Because the anaerobic decomposition of OM generally is less efficient that aerobic processes, OM tends to accumulate to greater degrees under hydric soil conditions leading to the formation of thicker and darker A horizons or even the formation of O horizons. It is postulated that the nature of the OM in hydric soils may also differ qualitatively from that in better drained soils.

DESCRIBING HYDRIC SOILS

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Implications of hydric soil interpretations on land-use necessitate detailed and objective morphological characterization of soil profiles. To apply the *Field Indicators of Hydric Soils* an especially careful assessment of the upper 50cm is needed, and complete characterization of the entire profile is recommended to better understand soil-hydrologic relationships. The primary objective is to characterize and document the presence or absence of morphological features which signify anaerobiosis in the soil profile. These include features related to 1) organic matter accumulations, and 2) the reduction, translocation, and/or accumulation of iron and manganese. Using principally the senses of sight and touch in conjunction with knowledge gained through experience, one must 1) estimate percent organic matter, distinguish between organic, mucky modified mineral or mineral soil materials, and between muck versus peat, 2) precisely identify soil matrix and redox feature colors and degree of contrast, and 3) identify the kind, pattern, size, quantity, and boundary condition of redox features and distinguish them from other mottles. In applying the *Field Indicators* one should be cognizant of the significance of depths and thickness of horizons, along with special rules of application (e.g. chroma should not be rounded down to meet an indicator.) Detailed documentation of soil morphology should provide insight into pedogenic processes, should support proper selection of indicators when present, and aid in making decisions regarding the hydric status of soils.

INTERPRETING REDOXIMORPHIC FEATURES

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Redoximorphic features form in soils when iron or manganese oxides are reduced, dissolved, and move through the soil to accumulate in other places. The features go by many names including mottles, low chroma colors, redox depletions, redox concentrations, etc. This presentation will review the factors needed to form redoximorphic features, discuss the step-by-step processes needed for their formation, and will summarize what the features tell us about how long soils are saturated and reduced. Redoximorphic feature formation occurs in the portions of the soil that become anaerobic because microbes are respiring and utilizing oxygen, iron, and manganese as their electron acceptors. The reduction generally occurs at microsites in the soil where the reductionprocesses are most intense. The microsites will generally become a gray color following reduction and diffusion of iron out the site. Iron oxidizes at points where oxygen penetrates the soil. The interpretation of redoximorphic features is straightforward: redox depletions (gray colors) show where reducton has occurred via bacterial respiration, while redox concentrations (red or yellow colors) show where oxidation has occurred. Relating the features to periods of saturation is more difficult because reduction does not occur as soon as a soil saturates. Typical cases will be reviewed.

AN EXPLANATION OF THE HYDRIC SOIL TECHNICAL STANDARD AND "NORMAL" PRECIPITATION

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Field Indicators have been developed for on-site identification of hydric soils. These indicators have been establishing by combining the best professional judgement of practicing wetland soil scientists with data generated by participating research soil scientists. Often we assume that soils with a field indicator are hydric and soils without a field indicator are nonhydric. This assumption may or may not be correct. All soils with an indicator may not, in fact, be hydric. Conversely soils without an indicator may, in fact, be hydric. Presently there is no approved methodology to be used in proving the hydric status of a soil with site specific data. Therefore, it is necessary to have a technical standard based on soil properties that reflect the hydric soil definition. The National Technical Committee for Hydric Soils (NTCHS) has developed specific requirements for measurement of saturation, reduction/oxidation potential, reduced iron (Fe^{++}), in-situ pH, and on-site precipitation data. The technical standard for hydric soils establishes threshold value requirements and instrumentation methodology for data collection. Guidelines have been developed by the NTCHS for the interpretation of each data set. To be useful for improving the field indicators or proving the hydric status of a specific site, the data must be collected during "normal" precipitation months.

USE OF FIELD INDICATORS OF HYDRIC SOILS

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When identifying a jurisdictional wetland, the hydric soil parameter is one of three parameters that needs to be met. The Corps of Engineers 1987 Wetland Delineation Manual gives a definition, criteria, and indicators that can be used to identify a hydric soil. All hydric soils must meet the definition of a hydric soil. The hydric soils criteria were created as a computer query to identify hydric soil series in the Natural Resources Conservation Service database. Some of the criteria can be used in the field to assist in the identification of a hydric soil, while other criteria should not be used in the field. The 1987 manual hydric soils field indicators were a good attempt at the time they were written to identify physical properties of the soil that could be used to indicate that the soil meets the definition of a hydric soil. However, these indicators are vaguely written and not always reliable for making a definitive call. And, for some regions of the country, such as areas dominated by red parent material, the indicators do not work at all. More recently the Field Indicators of Hydric Soils in the United States have been developed by the National Technical Committee for Hydric Soils. These new field indicators are updated using research conducted on hydric soils and are more specific regional indicators that, unlike the 1987 manual indicators, are proof positive. Therefore, if you meet an indicator the soil is a hydric soil. These new indicators also provide field indicators for some of the problem soils. Jurisdictional wetland determinations done under section 404 of the Clean Water Act require the use of the 1987 manual. Because of this the Field Indicators of Hydric Soils in the United States can only be used in support of a 1987 manual indicator or they can be used as stand alone indicators if the soil is a problem soil that does not develop 1987 Manual indicators. For Food Security Act determinations it is a requirement that the Field Indicators of Hydric Soils in the United States be used.

FIELD INDICATORS OF HYDRIC SOILS IN THE UNITED STATES

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Field Indicators of Hydric Soils in the United States was first published in 1996, a second edition was published in 1998. The indicators were developed by the NRCS and the National Technical Committee for Hydric Soils in cooperation with the USFWS, USACE, EPA, state and local agencies and university researchers. The Field Indicators are a culmination of research and practical field expertise and are the state of the science. This presentation provides an introduction to the publication, an overview of the terminology, and uses specific examples to illustrate the major concepts.

HYDRIC SOIL MONITORING

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Monitoring hydric soils will be considered at two levels of technology, manual and data recorders. Which one is chosen depends upon two restrictions; time and money. Manual reading require an initial investment, but the major investment is time. Once the decision is made as to what will be monitored, sufficient money to purchase the minimal field installations can be determined. A commitment must be made to collect data at regularly scheduled times if the manual route is chosen. Data recorders are usually chosen to overcome time and location restraints. The data needed to achieve various objectives will be presented. I will discuss the installation of sensors to obtain a minimum data set for both manual and recording options based upon several scenarios. I will show the installation video from the Florida site.

PROBLEM HYDRIC SOILS

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Most wetland soils tend to exhibit diagnostic hydromorphic features reflecting hydric soil conditions. However, a number of hydric soils are not so easily recognized. The 1987 ACOE Manual mentions problematic hydric soils including red parent material soils and sandy soils. The 1989 federal interagency wetland delineation manual and recent ACOE headquarters guidance lists others including: Entisols, Spodosols and Mollisols. Experienced soil scientists also recognize that the separation between hydric and non-hydric can be difficult in soils with high clay content (vertic soils). This presentation provides an overview of the topic, including the more frequently encountered problematic soils that occur throughout the U.S. Findings from recent soil monitoring studies will be presented along with suggested techniques for identifying problem hydric soils. The focus will be on problem hydric soils of the Mid-Atlantic and northeastern U.S.

HYDRIC SOILS AND WETLAND FUNCTIONS

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Hydric soils play a direct role in the wetland functions of water retention, sedimentation, and biogeochemical cycling of nutrients. In turn, these functions contribute to the development of hydric soils. Water retention contributes to anaerobiosis; sedimentation and carbon sequestration provide inputs for soil formation. Critical to the development of hydric soil indicators and to the cycling of nitrogen, carbon, sulfur, iron and manganese are oxidation-reduction (redox) reactions. Redox reactions are characterized by the transfer of electrons from one compound to another. Reduction of nitrate and nitrite (denitrification) removes nitrogen from water systems and returns it to the atmosphere as nitrous oxides. Redox reactions of iron and manganese produce many of the hydric soil indicators such as a depleted matrix and iron/manganese concretions. Reduction of sulfate to hydrogen sulfide leads to the loss of sulfur to the atmosphere in brackish and salt water systems and produces the 'rotten egg' smell. Reduction of carbon dioxide results in the production of methane (swamp gas). Redox reactions are both chemically driven and microbially mediated. Hydric soils provide the chemical environment and a habitat for microorganisms. The efficiency of wetlands in biogeochemical cycling is due to the close proximity of aerobic and anaerobic zones, and cycles of aerobiosis and anaerobiosis in hydric soils.

USING GIS AND SSURGO TO PREDICT HYDRIC SOIL OCCURRENCE

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Environmental regulators, planners, consultants and scientists are mandated to identify wetland resources, based in part on occurrence of hydric soils and near surface hydrology. Much of this data for broad assessment and regional planning is contained in printed soil survey reports, but may be fragmented and cumbersome to use. Recent software and hardware advances have enabled the standard printed surveys to be converted to a digital product (SSURGO) that can be easily viewed and manipulated to produce new information. This and other digital data is available online and can be downloaded and incorporated into a Geographic Information System (GIS) using ArcView™ software. A procedure will be demonstrated to build a GIS and then query the spatial data, tabular data, and point data to predict occurrence of hydric soils and potential wetlands across the landscape.

REGIONAL FIELD INDICATORS FOR IDENTIFYING HYDRIC SOILS IN NEW ENGLAND

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With its origins beginning in the mid 1980s as a cooperative effort by professionals in the private and public sectors and regulators to simplify and standardize hydric soil identification and delineation, the Field Indicators for Identifying Hydric Soils in New England (Version 2, July 1998) has evolved into a technical field guide recognized by scientists working in all six N.E. States. This is a field guide specific to the Region that takes the user through a systematic procedure for identifying hydric soils. It is a hierarchical key that requires the user to identify a combination of soil morphologies observed within specified depths. The key is presented in both a narrative and illustrative format and contains an extensive glossary and field guides for standardizing terminology and educating the user. Because this is a dynamic document that reflects current science as it evolves, the New England Hydric Soils Technical Committee (20 plus members) has been established to maintain the technical integrity of the Indicators and coordinate regional tours and field testing. More than 2,500 copies are in use throughout the Region.

QUANTIFYING REDOXIMORPHIC FEATURES IN A SEASONALLY PONDED WETLAND DEPRESSION: UPLAND SOILSCAPE IN SOUTHEASTERN TEXAS

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Redoximorphic features are very common in hydric soils and are important when identifying wetland areas and boundaries. An understanding of wetlands and their soil microbial processes facilitates application of agricultural technology to delineate wetland boundaries. The approach was to quantify redoximorphic features at four individual sites by using a grid that allowed individual soil features to be counted and described by color, size, and type. Final conclusions reached in this study include: 1) Fe accumulations observed at site 3W were quantitatively greater than all other sites; 2) At site 4W, accumulations of Mn were quantitatively greater than other 3 sites; 3) Redox accumulations of Mn at site 3W, demonstrated a significant difference from site 4W; 4) Redox accumulations of Fe in horizontal layers across 4 sites, produced observations of greater quantitative value at site 3W, but not a statistically significant difference. Vertical layers across 4 sites had a significant difference at sites 3W and 2W as compared to sites 4W and 3.5W; and 5) Redox accumulations of Mn in horizontal and vertical layers across 4 sites, demonstrated a quantitative and statistical difference between data observed at site 4W and the other 3 sites.

LONG-TERM HYDROLOGY AND REDOX PATTERNS OF SEASONALLY HYDROMORPHIC SOILS IN WESTERN KENTUCKY

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Ephemeral wetlands in western Kentucky exhibit high water tables only during late winter and early spring. Wetland designation is usually based upon the presence of hydric soil characteristics. A research study was initiated in 1993 aiming at establishing long-term hydrology, redox, hydric soil, and vegetation relationships and provide better documentation for delineating jurisdictional wetlands. Four sites involving eight soils developed from loess or loess alluvium were studied. Two of the sites represent catenas of three soils each, with poor to moderately good drainage conditions. Biweekly monitoring of the sites was performed with duplicate piezometers, redox probes and tensimeters at depths of 25, 50,100, and 150 cm. Vegetation evaluations were performed annually. Based on 6 year monitoring data, only three of the sites met all three wetland criteria. Five sites met wetland hydrology standards, but only four exhibited hydric soil indicators and experienced reducing conditions below 200 mV into the growing season. Endosaturation conditions appeared to be prevalent at the wettest sites in which high water tables and strong reducing conditions persisted well into the growing season. Episaturation conditions were associated with transient or inconsistent wetland characteristics. The findings of the study emphasize the need for comprehensive, long-term site evaluations for wetland delineation assessments.

THE MID-ATLANTIC HYDRIC SOILS COMMITTEE: A MULTIDISCIPLINARY PARTNERSHIP

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In March of 1996, the Mid-Atlantic Hydric Soils Committee was formed to address hydric soils issues in the Mid-Atlantic Region; Land Resource Regions R, S, T, L, and N. Members presently work together in an effort to pursue and identify important research needs and to establish a collection of information from which to better identify hydric soils in the field. Research is gathered from around the region and is compiled to develop better ways of making decisions regarding hydric soil determinations. Meetings are held bi-annually and committee members reflect a wide array of Federal, State and University interests from around this Region including; the Natural Resources Conservation Service, U.S. Fish and Wildlife Service, New Jersey Department of Environmental Protection, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, Maryland Department of the Environment, Wetlands Science Institute, University of Maryland, University of Delaware, Virginia Polytechnic Institute, and the National Technical Committee for Hydric Soils.

The Mid-Atlantic Hydric Soils Committee has developed a Regional Field Guide to the National Technical Committee's Hydric Soils Indicators entitled *Field Indicators of Hydric Soils in the Mid-Atlantic United States,* soon to be accompanied by a regional *Guide to Hydric Soils in the Mid-Atlantic States*. The Committee is also responsible for a number of research projects encompassing topics such as Piedmont HGM research, anomalous bright loamy soils (ABLS), red parent materials, ectomycorrhizal fungi and the analysis of regional indicators and user notes. In addition to supporting various studies, the Committee also accepts the responsibility of disseminating information throughout the interested community. Also, the Mid-Atlantic Hydric Soils Committee now hosts a web site located at **http://www.epa.gov/reg3esd1/hydricsoils/index.htm** and has organized the first National Hydric Soils Workshop in cooperation with the Wetlands Regulatory Workgroup.

PROBLEM SOILS IN THE MID-ATLANTIC REGION

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Certain soils have been recognized as problem hydric soils because they lack morphological features expected for hydric soils. Three groups of problem soils found in the Mid-Atlantic region will be addressed: 1) red parent material soils; 2) anomalous bright loamy soils; and 3) piedmont floodplain soils. Red Parent Material soils are inherently resistant to developing low chroma depletions, and a more subtle set of rexodimorphic features can be used to delineate these hydric soils. A color change propensity index (CCPI) has been developed to determine when it is appropriate to invoke the use of these alternative field indicators (ie.TF2). Loamy textured soils have been identified at low elevations (<5 m above MSL) on the Mid-Atlantic Coastal Plain which possess seasonally high water tables and may be hydric soils, but do not show morphological features typical for wet soils. There are several possible explanations for this phenomenon related to 1) Environmental Factors (hydrological or biogeochemical) or 2) Parent Material/Mineralogical Factors. In Piedmont flood plains, young alluvial soils have formed in deposits which have accumulated since the time of colonial settlement. While redox concentrations of Fe and Mn are abundant, soils often lack the depleted matrix colors (chroma 2 or less) characteristic of most hydric soils. What is uncertain is whether the absence of low chroma colors indicates that hydric soil conditions are not present or whether this is merely a reflection of the youthful nature of soils which are hydric.

BURIED THICK DARK SURFACES: PROBLEMS IDENTIFYING AQUIC CONDITIONS AND HYDRIC SOILS

Wheeler, Daniel B. and Jay C. Bell, University of Minnesota, Department of Soil, Water & Climate, 1991 Upper Buford Circle, 439 Borlaug Hall, Saint Paul, MN 55108.

Soils possessing thick dark surface horizon(s) have long been known to cause problems for hydric soil determinations due to high amounts of organic matter and have been identified as problem soils. However, it is common in many Mollisol landscapes to discover that upslope sediments bury the thick dark surface, especially where upslope land-use alterations have occurred. These upslope sediments are positioned over the thick dark soil surface and may not convey the contemporary hydrological regime due to their recent deposition. Therefore many of these upslope sediments do not meet the color criteria for either the thick dark surface field indicator for hydric soils (F5) or the thick dark surface 2/1 test field indicator (TF7). We have compiled soil morphological observations across several physiographic regions of Minnesota in order to demonstrate the prevalence of upslope sediments in concave landscape positions. We will also characterize these depositional sediments placing emphasis on field indicators of hydric soils. Anecdotal field observations and suggestions for modified indicators will also be discussed.

FUNGI AS INDICATORS OF HYDROLOGY

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Hydrology indicators are often difficult to find in seasonally-saturated wetlands in which inundation is rare. A potential indicator is ectomycorrhiza, a symbiosis between fungi and higher plants. Ectomycorrhizae form with trees from the following families: Aceraceae, Betulaceae, Cupressaceae, Fagaceae, Leguminosae, Pinaceae, Rosaceae, Salicaceae, and Ulmaceae. Therefore, they are likely to be found in most woods in the mid-Atlantic region. The fungi that form ectomycorrhizae are the same fungi that produce mushrooms and puffballs. They are aerobic organisms and the symbiosis is suppressed by anaerobic conditions. Evidence of the symbiosis is a 'mantle', a layer of fungal hyphae that covers root tips. The mantle is visible to the naked eye. It is stable; it forms early in the growing season and usually remains intact throughout the growing season. Because of these characteristics, the depth that the mantles are found in the soil should reflect the depth of the seasonally-high water table. Recent research conducted on the Delmarva Coastal Plain indicates that ectomycorrhizae are rarely found below a soil depth of two inches in wetlands. However, in uplands they commonly occur deeper than two inches.

FACTORS AFFECTING WATER TABLE FLUCTUATIONS IN HYDRIC SOILS

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Water table fluctuations in poorly drained soils are dependent on soil physical properties, site conditions and climatological factors. This paper examines the effect of soil properties and site conditions on water table fluctuations in relatively flat hydric soils that are not influenced by seepage or runoff from upslope areas, nor by flooding from adjacent streams. DRAINMOD simulations and recorded water table data from a range of poorly drained eastern NC soils were analyzed to determine the effects of soil properties and site conditions on water table depth and fluctuations. Results showed that drainable porosity, which is a function of the more basic soil property, the soil water characteristic (or suction release curve), has a big influence on the rate that the water table falls or rises. The other important factor is the relationship between drainage rate and water table elevation. This relationship is a function of the hydraulic conductivity and depth of soil layers, distance to and depth of natural or man made drains, and other factors controlling vertical and lateral seepage. Depth of depressional surface storage also affects water table response to rainfall, evapotranspiration and drainage. Examples are presented to demonstrate how the interaction of these factors affect water table fluctuations in wetlands and poorly drained uplands.

DEVELOPMENT OF REDOXIMORPHIC FEATURES IN A PALUSTRINE FORESTED MITIGATION SITE IN VIRGINIA

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The rate of formation of hydric soils and associated redoximorphic features in mitigation sites has not been well documented. This study was conducted to examine differences in soil morphology along a wetness gradient in a mitigation site and an adjacent natural wetland. As a part of a larger geohydrologic study, soil morphology was observed along three wetness transects in the eight year-old Fort Lee, Virginia, mitigation site and adjacent reference area soils. Iron concentration (primarily oxidized rhizospheres) presence in the soils increased with longer periods of saturation. In surface horizons, oxidized rhizospheres were more abundant and prominent in areas saturated for longer periods at or above the surface. Hydrologic regimes of mitigation areas generally showed larger differentials between seasonal high and low water tables than reference areas. Though the drier soils in the study were clearly "wet enough" to meet jurisdictional criteria, they still supported a dominance of upland and facultative upland vegetation. Testing for Fe(II) with alpha-dipyridyl dye solution produced mixed results. Oxidized rhizospheres, associated with active root channels in surface horizons, formed in less than ten years under the current hydrologic conditions. A site-specific model for iron concentration abundance vs. drainage was developed.

SOIL PROPERTIES FOR WETLAND ASSESSMENT

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Wetlands function to regulate and partition water flow through the environment, buffer environmental change, and as a medium for plant growth. Soil properties that reflect hydrologic and biogeochemical processes should be used as indicators of wetland function. A review of pertinent soil properties for wetland assessment will be presented. Soil lab data and field morphology from over 100 wetlands in the Prairie Pothole Region of the U.S. will be reviewed. The lab data will be compared with a derived soil quality morphological index that could be used to increase the scientific validity of rapid field assessment of wetlands.